The bird remains from wf16, an early neolithic settlement in southern Jordan: assemblage composition, chronology and spatial distribution

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RESEARCH ARTICLE

The bird remains from WF16, an early Neolithic settlement in southern Jordan: Assemblage composition, chronology and spatial distribution

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Abstract

Excavations at the early Neolithic settlement of WF16 in Faynan, southern Jordan, 11.84–10.24 ka BP, recovered 17,700 bird bones, of which 7808 could be identified to at least family level. Sixty-three different bird taxa are present from 18 families, representing a mix of resident and migrant birds, based on present-day ecology. We describe the settlement context for the assemblage, its taxonomic composition, spatial and chronological distribution, identifying its similarities and differences to avian assemblages from broadly contemporary sites in the region.

KEYWORDS
bird bones, chronology, distribution, Faynan, Jordan, Neolithic, WF16

1 | INTRODUCTION

The emergence of the Neolithic in SW Asia was a gradual process between 20,000 and 8000 years ago, with a particularly intense period of change during the Pre-Pottery Neolithic A (PPNA) period, ca. 12,000–10,000 years ago (Goring-Morris & Belfer-Cohen, 2011). While Neolithic research has focused on the domestication of goat, sheep, cattle and cereals, a wholesale change in the relationship between humans and the natural world is likely to have occurred, influencing human relationships with birds. As recorded throughout history and in the modern day, people have diverse economic, symbolic, social and ecological relationships with birds (Cocker & Tipling, 2013). It is not unreasonable to assume the same would be the case for the Neolithic of SW Asia and that by exploring such relationships we may gain insights into the cultural changes associated with the transition from mobile hunting and gathering to settled farming communities that go beyond the domestication of plant and animals.

Avian fauna has been described from several Epipalaeolithic and PPNA sites in the Levant, with interpretations encompassing the use of waterfowl as food (e.g., Simmons, 2004; Yeomans & Richter, 2018) and attributing symbolic significance to large birds such as cranes and raptors (e.g., Gourichon, 2002; Zeder & Spitzer, 2016), such birds also being prominent in representations at Göbekli Tepe and Jerf el Ahmar (Peters et al., 2005). Avian assemblages tend to be small, an exception being that from the Late Natufian of Shubayqa 1 in northeast Jordan with 3090 NISP (Number of Identified Specimens; Yeomans & Richter, 2018). Those from Hallan Çemi in the northern Levant (Zeder & Spitzer, 2016), Netiv Hagdud (Tchernov, 1994) and Ohalo (Simmons & Nadel, 1998) in the southern Levant have just over 1000 NISPs (1154, 1138 and 1350, respectively) while significantly smaller assemblages have been recovered from An Darat ($n = 24$), Fazel VI ($n = 31$), Salabiya IX ($n = 72$) and Gilgal ($n = 51$) (Howitz et al., 2010; Simmons, 2004). Considering the multitude of taphonomic factors that influence avian assemblages, many of which are especially fragile, and the range of potential people–bird relationships that might have existed, drawing robust inferences from such collections is problematic.

This concern applies to the avian assemblage acquired from the archaeological evaluation of the PPNA site of WF16 in southern Jordan, consisting of 249 NISP (Rielly, 2007). That assemblage had a predominance of raptors including eagles, vultures and buzzards, contrasting with the avian assemblages from PPNA sites elsewhere in the southern Levant that are dominated by waterfowl and game birds (Simmons, 2004). This contrast, however, might have arisen from the small sample acquired at WF16, which was excavated from a limited spatial area and may be unrepresentative of the whole settlement. The extensive WF16 excavations undertaken between 2008 and 2010 provided a significantly larger avian assemblage, one of almost 18,000 specimens with 7808 NISP, derived from a wide range of structures and depositional contexts at the site. Assemblage size is, of course, just one factor of importance; others include quality of preservation and contextual information including associated artefacts, mammalian fauna and plant remains. These are also relatively high at WF16, providing the opportunity to explore a diverse range of human–bird relationships at one particular settlement during the PPNA phase of the Neolithic transition. Moreover, there are 676 burnt specimens and 493 bones exhibiting cut marks within the 7808 NISP, these being subject of on-going study.

1.1 | Faynan and the WF16 settlement

WF16 is an early Neolithic settlement in Faynan, southern Jordan, located approximately 50 km south of the Dead Sea (Figure 1). The Faynan region includes flat and hilly areas to the east of Wadi Araba and covers Wadi Faynan, Wadi Fidan and the lower parts of Wadi Dana and Wadi Ghuwayr, primarily at approximately 400 m asl, prior to the land climbing steeply to the Jordanian plateau at approximately 1500 m asl. The present-day climate is arid with hot summers and mild winters, with a mean annual temperature of 24°C and mean annual precipitation of approximately 60 mm. Rain falls occasionally during the cooler winter months, when average temperatures are 15° lower than in the summer.

Today, Faynan is part of the Sudanian penetration zone as characterized by the presence of African trees and shrubs, for example, acacias (*Acacia tortilis* and *Acacia raddiana*), jujubes (*Ziziphus spina-christii*) and *Moringa peregrina*. However, plant species of Saharo-Arabian origin are also common such as the desert broom (*Retama raetam*), the white saxaul (*Haloxylon persicum*) and the dwarf shrubs *Anabasis articulata* and *Zygophyllum dumosum* (Albert et al., 2004). Dense riverine woodland is located along a permanent water course in the Wadi Ghuwayr (Mithen et al., 2007), while the upper reaches of the region fall within the Mediterranean woodland zone. This mix of habitats results in a diverse avian fauna of both resident and migratory species; 187 species have been recorded, 42 of which are resident all year round while the others pass through on spring and autumn migrations between Africa and Europe (Al-Shamlih et al., 2005; Andrews, 1995). Faynan is located on the rift valley migratory route resulting in large flocks of raptors, cranes and other migratory birds passing overhead and sometimes resting in the area.

WF16 is located at the confluence of Wadi Ghuwayr and Faynan, at the base of the escarpment that climbs to the Jordanian plateau. The site was discovered in 1996 and evaluated between 1997 and 2003 (Finlayson & Mithen, 2007). An area excavation of WF16 was undertaken between 2008 and 2010 (Mithen et al., 2018; Figure 1). This revealed numerous, densely clustered semi-subterranean structures that had been used for domestic activities, storage, workshops and gathering places. These structures, along with other distinct structural elements of the settlement, such as floors, middens and pits, are referred to as 'Objects'. For instance, a large communal structure, one of a unique size and design for the Neolithic (Mithen, 2020), is referred to as Object 75 (O75) and an extensive area of midden as O60.

Although none of these structures were entirely excavated, with only approximately 20% of the total deposits removed, 213,065 L of sediment were dry sieved for finds, which included 578,538 g of animal bone (within which the bird bones were contained) and 2,731,306 g of chipped stone tools and debitage. Work is on-going on these and others finds, including stone and shell beads, plant remains, bone tools and incised stone. Initial assessment indicates that the animal fauna is consistent with that from the 1997–2001 assessment: a dominance of *Capra* sp. with the presence of *Gazella*, *Bos*, equids and a low frequency of carnivores (Carruthers & Dennis, 2007). Archaeobotanical remains suggest exploitation of diverse wild plants with a possibility of cultivation of wild barley (Mike Charles, pers. comm), similar to that evident from contemporary settlements (e.g., Dhra; Colledge et al., 2018).

Radiocarbon dating (Wicks et al., 2016) and use of chipped stone typology have identified three phases of activity at WF16:

Phase 1: 11.84–11.30 ka BP, represented by small sub-circular, semi-subterranean structures with mud and stone walls. These were scarce and poorly preserved, providing few remains. Only one structure exposed in the 2008–2010 excavation may be related to this phase of activity, Structure O73. This requires confirmation from absolute dating and hence for this article we include it within Phase 2 activity.

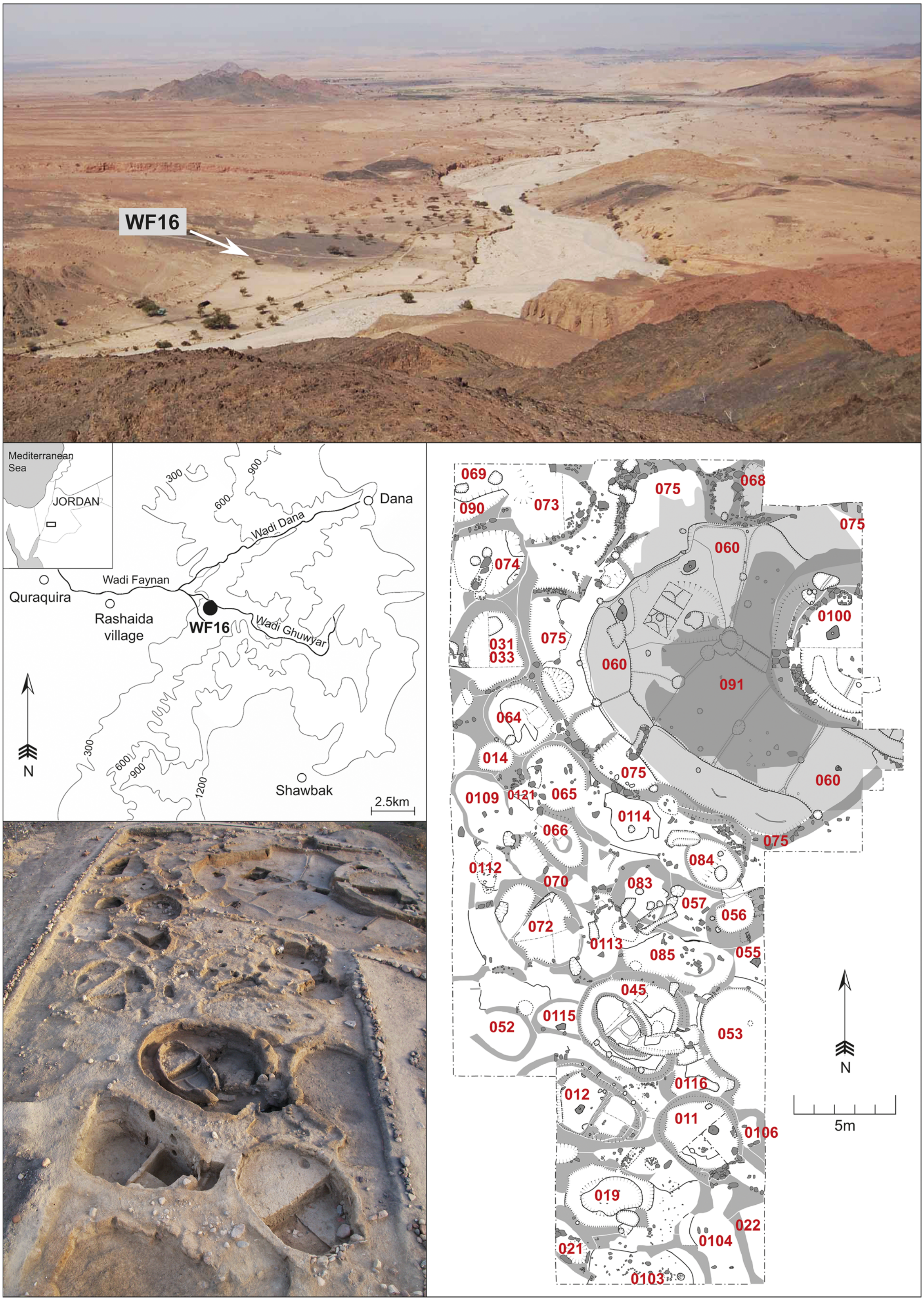

FIGURE 1 The early Neolithic site of WF16 (a) looking east along the Wadi Faynan towards the Wadi Araba; (b) location in southern Jordan (c) excavation in April 2010; (d) site plan [Colour figure can be viewed at wileyonlinelibrary.com]

Phase 2: 11.30–10.80 ka BP, represented by a dense cluster of semi-subterranean pisé-walled structures, of various designs and sizes including the larger communal structure O75.

Phase 3: 10.80–10.24 ka BP, principally represented by a freestanding circular pisé- and stone-walled structure (O100) constructed within O75 with an external mud-plaster floor (O91), and the contents of a large midden (O60) that accumulated in its surrounds. Most of the burials are attributed to this phase, these having been inserted into Phase 2 deposits, although horizontal truncation of deposits makes this attribution uncertain.

These developments suggest significant social and economic change occurred during the course of occupation at WF16, involving longer periods of occupation at the settlement, potentially leading to sedentism.

2 | METHODS

Over 200,000 bone specimens were recovered from WF16 by sifting all sediments through a 2-mm mesh or from flotation, ensuring near-total recovery of small bird bones in addition to small and medium mammal remains. The avian and other faunal remains derived from a variety of depositional environments including occupational debris, small 'private' rubbish pits, large middens and potentially ritual depositions.

The bird bones were separated from the faunal remains (by Cheryl Makarewicz) and identified (by Judith White) using the comparative collection of the Natural History Museum, Tring, UK, alongside published identification criteria and measurement data in the literature (Cohen & Serjeantson, 1996; Gilbert & Martin, 1981; Matarranz, 2017a, 2017b; Otto, 1981; Schmidt-Burger, 1982; Tomek & Bocheński, 2000). Bones were identified to species whenever possible, although many were only possible to genus or family level due to their fragmentary nature, while unidentified fragments were assigned to size categories. The taxonomic order and nomenclature follow Howard & Moore 4th Edition (Dickinson & Christidis, 2014; Dickinson & Remsen, 2013).

The zoning system according to Cohen and Serjeantson (1996) was used to record bone completeness for most elements, to allow for quantification of minimum number of elements (MNE) and minimum number of individuals (MNI). Observations on the type of break, state of preservation, taphonomy, butchery, burning, gnawing, pathology, sex and maturity were also recorded. Measurements were taken following Cohen and Serjeantson (1996) and Von den Driesch (1976).

3 | RESULTS

3.1 | Family/taxa representation

The bird bones from WF16 total 17,700 fragments, of which 7808 could be identified to at least family level, or the order of Passeriformes (Table 1). Sixty-three taxa from 18 families were identified, along with some tentative identifications at passerine family level and represents a diverse mix of resident and migrant birds from a variety of habitats, based on present-day ecology.

Despite the large range of species, the Accipitridae family dominate the assemblage accounting for 89.19% of identifiable bones (NISP = 6964) with at least 20 species of eagles, vultures, harriers, kite, sparrowhawk and buzzards represented (Figure 2). The Eurasian/steppe buzzard is by far the most abundant accounting for 63.19% of all Accipitridae (NISP = 4401). The steppe buzzard (*Buteo buteo vulpinus*) is a subspecies of the Eurasian buzzard and is a very frequent passage migrant to the region. The Eurasian buzzard is a scarce migrant but due to the similarities of skeletal morphology they are referred to as Eurasian/steppe, although it is most likely the bones derive from the steppe subspecies. The European honey buzzard (*Pernis apivorus*) is the second most common species in the assemblage with a total NISP of 345 and is another common passage migrant. The third most common bird of prey is the kite (NISP = 181). Bone fragments were identified only to the genus *Milvus* due to the similarities in skeletal morphology of red and black kite; however, it is most likely the bones belong to black kite (*Milvus migrans*) based on their current distribution and status in Jordan today as a frequent passage migrant. Raptors from other families are also represented in small numbers: Falconidae (NISP = 50), Strigidae (NISP = 9) and Tytonidae (NISP = 2).

Phasianidae is the second largest family accounting for 3.93% (NISP = 307) of the identified material with the resident, ground dwelling chukar partridge (*Alectoris chukar*) most frequent (NISP = 254) and the sand partridge (*Ammoperdix heyi*) and quail (*Coturnix coturnix*) making up the remainder. Somewhat unexpectedly, the third largest family at 0.97% is Threskiornithidae, which includes 70 specimens identified confidently to northern bald ibis (*Geronticus eremita*) and a further six as probable, making it the fifth most common bird in terms of NISP. Ducks, storks, herons, bustard, rails, doves, rollers, corvids and some smaller passerines are also represented, often only by single bones or in the case of the little egret (*Egretta garzetta*) a near complete individual.

3.2 | Taxa distribution by phase

The absence of bird bones from Phase 1 reflects the sparse representation of these deposits at WF16. Sixty taxa were identified from Phase 2 and 41 taxa from Phase 3. This difference may be a consequence of assemblage size: 14,965 (NISP = 6396) and 2735 (NISP = 1412) bones, respectively, which in turn may reflect the quantity of sediment excavated: 120,946 L for Phase 2 and 92,119 L for Phase 3. Species such as crane and European roller are absent in Phase 3, along with a smaller range of owls, corvids and diurnal raptors. While the Accipitridae family dominates the assemblage in both phases, its contribution decreases from 90.40% of identified bones in Phase 2 to 83.64% in Phase 3. As a result, Phasianidae, Anatidae, Ciconiidae, Pteroclidae and Columbidae increase in relative frequency in Phase 3. Sandgrouse (Pteroclidae) show the most substantial

TABLE 1 NISP and MNI for taxa at WF16 by phase

	Phase 2		Phase 3			
Taxon	NISP	MNI	NISP	MNI	Resident/migrant	Found in Faynan today
Anatidae						
Anser cf. *anser*			1	1	Migrant	No
cf. *Anser* sp.	1	1				
Aythya cf. *ferina*	1	1			Migrant	No
Aythya cf. *fuligula*			1	1	Migrant	No
cf. *Aythya* sp.	1	1				
Mareca cf. *strepera*	1	1	1	1	Migrant	No
Mareca cf. *penelope*			4	1	Migrant	No
Anas cf. *platyrhynchos*	3	1			Migrant	Yes
Mareca penelope/*Anas platyrhynchos*	3	1	3	1		
Anas cf. *acuta*			1	1	Migrant	No
Anas cf. *crecca*	4	2	1	1	Migrant	Yes
Anas crecca/*querquedula*	6	1	3	1		
Anas sp.	6	2	12	2		
cf. *Anas* sp.	2	1				
Anas/*Aythya* sp.			3			
Totals	28		30			
	0.44%		2.12%			
Phasianidae						
Coturnix coturnix	19	5	10	2	Migrant	Yes
Alectoris chukar	197	20	57	8	Resident	Yes
cf. *Alectoris chukar*	3	1				
Francolinus/*Alectoris* sp.	3		2			
Ammoperdix heyi	10	3	4	2	Resident	Yes
cf. *Ammoperdix heyi*	1	1				
Phasianidae medium	1					
Totals	234		73			
	3.66%		5.17%			
Columbidae						
Columba cf. *livia*	5	2	3	1	Resident	Yes
Columba cf. *oenas*	2	1			Migrant	No
Columba oenas/*livia*	27	6	15	4		
Columba palumbus	1	1			Migrant	No
Columba sp.	1	1	2	1		
Streptopelia decaocto	2	1	5	2	Resident	Yes
cf. *Streptopelia decaocto*			1	1		
Streptopelia/*Columba* sp.	2					
Totals	40		26			
	0.63%		1.84%			
Pteroclidae						
Pterocles cf. *senegallus*			8	3	Resident	Yes
Pterocles sp.	3	3	39	8		
Totals	3		47			
	0.05%		3.33%			

(Continues)

TABLE 1 (Continued)

Taxon	Phase 2 NISP	Phase 2 MNI	Phase 3 NISP	Phase 3 MNI	Resident/migrant	Found in Faynan today
Rallidae						
Crex crex	18	3			Migrant	Yes
cf. *Crex crex*	3	1	2	1		
Gallinula chloropus	1	1			Migrant	Yes
Fulica atra	3	1	3	1	Migrant	No
Totals	25		5			
	0.39%		0.35%			
Gruidae						
Grus grus	1	1			Migrant	Yes
Grus/Ciconia sp.	1					
Totals	2					
	0.03%					
Otididae						
Chlamydotis sp.	6	1	2	1	Resident	Yes
Totals	6		2			
	0.09%		0.14%			
Ciconiidae						
Ciconia cf. *ciconia*	14	2	7	1	Migrant	Yes
Ciconia sp.	13	2	2	1		
Totals	27		9			
	0.42%		0.64%			
Ardeidae						
Ixobrychus minutus	1	1			Migrant	No
Ardea purpurea	1	1	1	1	Migrant	No
Egretta garzetta	56	1			Resident	Yes
Totals	58		1			
	0.91%		0.07%			
Threskiornithidae						
Geronticus eremita	57	5	13	2		No
cf. *Geronticus eremita*	4	1	1	1		
Platalea leucorodia/Geronticus eremita	1					
Totals	62		14			
	0.97%		0.99%			
Accipitridae						
Pandion haliaetus	14	2	1	1	Migrant	No
cf. *Pandion haliaetus*	4	1				
Pernis apivorus	291	15	54	6	Migrant	Yes
cf. *Pernis apivorus*	42	4	5	2		
Neophron percnopterus	2	1	2	1	Migrant	Yes
cf. *Neophron percnopterus*	1	1	1	1		
Circaetus gallicus	25	2			Migrant	Yes
cf. *Circaetus gallicus*	10	1	1	1		
Torgos tracheliotos	1	1				No
Clanga cf. *pomarina*	37	4	8	2	Migrant	Yes
Clanga cf. *clanga*	17	2			Migrant	Yes

TABLE 1 (Continued)

Taxon	Phase 2 NISP	Phase 2 MNI	Phase 3 NISP	Phase 3 MNI	Resident/migrant	Found in Faynan today
Clanga pomarina/clanga	6	1	2	1		
Aquila cf. *nipalensis*	32	2	8	1	Migrant	Yes
Aquila cf. *heliaca*	1	1			Migrant	Yes
Aquila cf. *chrysaetos*	4	1			Migrant	No
Aquila chrysaetos/nipalensis	2	1				
Aquila cf. *verreauxii*	2	1			Migrant	No
Aquila cf. *fasciatus*	3	1			Resident	Yes
Aquila sp.	10	2	2	1		
Aquila large	7		1			
cf. *Aquila* sp.	22	2				
Aquila/Buteo sp.	23		10			
Aquila/Hieraaetus sp.	11		11			
Hieraaetus pennatus	8	1	3	1	Migrant	Yes
Hieraaetus cf. *pennatus*	3	2	4	3		
Hieraaetus sp.	1	1	1	1		
Hieraaetus/Buteo sp.	2					
Circus cf. *aeruginosus*	17	2	4	3	Migrant	Yes
Circus cf. *cyaneus*	9	2	1	1	Migrant	Yes
Circus cyaneus/macrourus	18	2	7	1		
Circus cf. *pygargus*	5	1	2	1	Migrant	Yes
cf. *Circus* sp.	6	1	1	1		
Circus/Buteo sp.	37		12			
Accipiter nisus/brevipes	20	4	3	1	Migrant	Yes
Milvus sp. (most likely *M. migrans*)	150	8	31	2	Migrant	Yes
cf. *Milvus* sp.	30	3	6	2		
Milvus/Buteo sp.	3		1			
Milvus/Pernis sp.	7		1			
Buteo cf. *buteo*	3670	127	731	56	Migrant	Yes
cf. *Buteo* sp.	765	32	171	11		
Buteo rufinus	35	3	5	1	Resident	Yes
Buteo cf. *rufinus*	37	2	7	2		
Accipitridae large	9		1			
Accipitridae medium	349		78			
Accipitridae medium/large	35		5			
Totals	5783		1181			
	90.40%		83.64%			
Tytonidae						
Tyto alba	2	1			Resident	No
Totals	2					
	0.03%					
Strigidae						
Otus scops	1	1			Migrant	Yes
Asio flammeus	1	1			Migrant	No
Strix sp.	2	1	1	1	Resident	Yes
Strix/Asio sp.	1					

(Continues)

TABLE 1 (Continued)

Taxon	Phase 2 NISP	Phase 2 MNI	Phase 3 NISP	Phase 3 MNI	Resident/migrant	Found in Faynan today
Bubo ascalaphus	2	1	1	1	Resident	Yes
Totals	7		2			
	0.11%		0.14%			
Coraciidae						
Coracias garrulus	2	1			Migrant	Yes
cf. *Coracias garrulus*	1	1				
Totals	3					
	0.05%					
Falconidae						
Falco cf. *tinnunculus*	5	2	2	1	Resident	Yes
Falco cf. *biarmicus*	27	3	2	1	Resident	Yes
Falco cf. *peregrinus*	5	1	1	1	Migrant	Yes
Falconidae small	2		1			
Falconidae small/medium	1					
Falconidae large	4					
Totals	44		6			
	0.69%		0.42%			
Corvidae						
cf. *Pyrrhocorax pyrrhocorax*	4	1				No
Corvus cf. *frugilegus*	1	1			Migrant	No
Corvus cf. *ruficollis*	4	1	1	1	Resident	Yes
Corvus cf. *rhipidurus*			1	1	Resident	Yes
Corvus rhipidurus/ruficollis	9	1	2	1		
Corvus cf. *corone cornix*	7	1			Resident	No
Corvus sp.	8	1	4	1		
Totals	33		8			
	0.52%		0.57%			
Other passerines						
Laniidae: *Lanius* cf. *excubitor*	1	1			Resident	Yes
Laniidae: cf. *Lanius* sp.	3	1	2	1		
Motacillidae: cf. *Motacilla* sp.	2	1				
Sylvidae: cf. *Sylvia* sp.	1	1				
Muscicapidae: cf. *Oenanthe* sp.	1	1				
Turdidae: *Turdus* cf. *viscivorus*	4	2			Migrant	No
Turdidae: *Turdus* cf. *merula*			1	1	Migrant	Yes
Turdidae: *Turdus* sp.	7	2	1	1		
Turdidae: cf. *Turdus* sp.	6	3	1	1		
Passerine small	11					
Passerine medium	3		3			
Totals	39		8			
	0.61%		0.57%			
Total identified specimens	6396		1412			
Unidentified small	5		3			
Unidentified medium	8505		1305			
Unidentified medium/large	47		13			

TABLE 1 (Continued)

	Phase 2		Phase 3			
Taxon	NISP	MNI	NISP	MNI	Resident/migrant	Found in Faynan today
Unidentified large	12		2			
Totals	8569		1323			
Total number of specimens	14,965		2735			

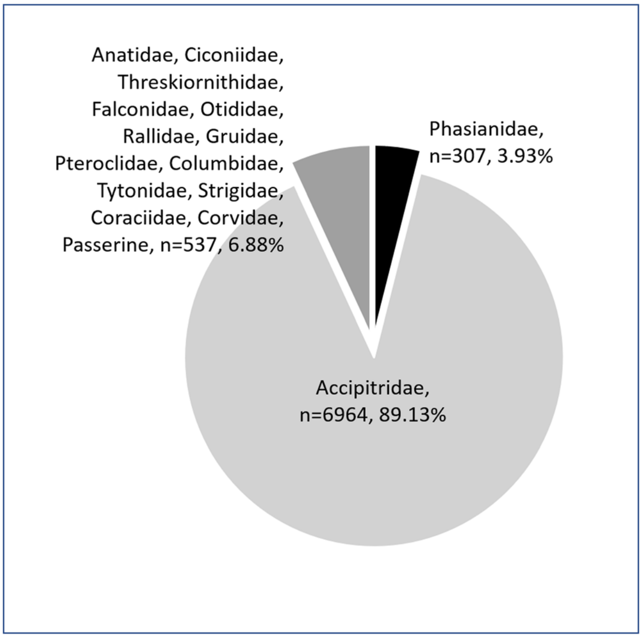

FIGURE 2 Frequencies of Accipitridae, Phasianidae and other taxa at WF16 [Colour figure can be viewed at wileyonlinelibrary.com]

change between Phase 2 (NISP = 3; MNI = 3) and Phase 3 (NISP = 47; MNI = 11).

When the quantity of sediment is accounted for, bird bones are four times more frequent within Phase 2 than in Phase 3: 0.124 bones/litre sediment compared with 0.03 bones/litre. This is in marked contrast to animal bone and chipped stone, both of which significantly increase in density in Phase 3. Within Phase 2, the ratio of the number of bird bones to the weight of animal bones (in grams) is 1:6, whereas in Phase 3, this ratio changes to 1:179. Similarly, regarding chipped stone, there is a change in the ratio of the number of bird bones to the weight of chipped stone (in grams) from 1:26 in Phase 2 to 1: 857 in Phase 3. These figures suggest the exploitation of birds was of significantly less importance for the Phase 3 than the Phase 2 inhabitants of WF16.

3.3 | Distribution by object

Bird bones were recovered from 47 Objects (or groups of Objects), a selection of which are shown in Figure 3. All objects were dominated by remains from Accipitridae, except Object 66 that contained a semi-articulated partial skeleton of a little egret. Table S1 provides details regarding the bird bone assemblage from 13 objects (or groups of objects) representing 85.35% of the total number of bird bones and 86.74% of those identified to taxa, summarized in Table 2.

As illustrated in Figure 4, there is marked variability in their distribution. Four objects contained 61% of the bird bones: O11 (16.14%), O45 (17.78%), O60 (13.50%) and O75 (13.41%). Of these, O11 also has the second highest density of bird bones (NISP/litre excavated sediment), and O45 the third highest, both surpassed by those from O56, a relatively small structure. Structures O60 and O75 are from Phase 3. While they had large quantities of bird bones, their densities are relatively low because of the large volumes of sediment excavated from these structures.

Figure 5 compares the distribution of the number of bird bones with the weights of animal bones and chipped stone in 10 structures of Phase 2, with the three data sets standardized to enable comparison (by subtracting the mean and dividing by the standard deviation for each value). As evident from the figure, the animal bone and chipped stone follow a similar distribution pattern with a strong correlation between their densities ($R^2 = 0.83$) suggesting they share a similar pattern of discard. In contrast, no such correlation exists between the density of bird bones and with either animal bones or chipped stone ($R^2 = 0.23$ and $R^2 = 0.06$, respectively). While O56 has the highest density of bird bones, the density of animal fauna and chipped stone is at an average level for the 10 structures under comparison, while these are below average in Object 11 which has the second highest density of bird bones. Conversely, Structures O53 and O73 have significantly above average densities of animal bone and chipped stone and below average levels of bird bones. Overall, it appears that the discard of bird bone in Phase 2 at WF16 was independent from that of animal fauna and chipped stone.

There is little to differentiate the composition of the high- and low-density bird bone assemblages. The three highest density assemblages also have the highest frequencies of Accipitridae of the identified bones, reaching 97.32% in O11 and above 93% in O56 and O45. O53 also surpasses 93% and all other structures have over 75% (other than O66 with the articulated partial skeleton of a little egret). Also, the two highest density assemblages have the lowest frequencies of burnt bones, 0.21% in O11 and 0.64% in O56 (again, excepting O66).

The little egret within Structure O66 is the only evident example of a burial or ritual deposition at WF16 (Figure 6). The head, neck, right upper wing, legs and feet were recovered as articulated remains from one bird that were found adjacent to a wall, possibly within a niche, and close to an installation, probably used to contain a stone

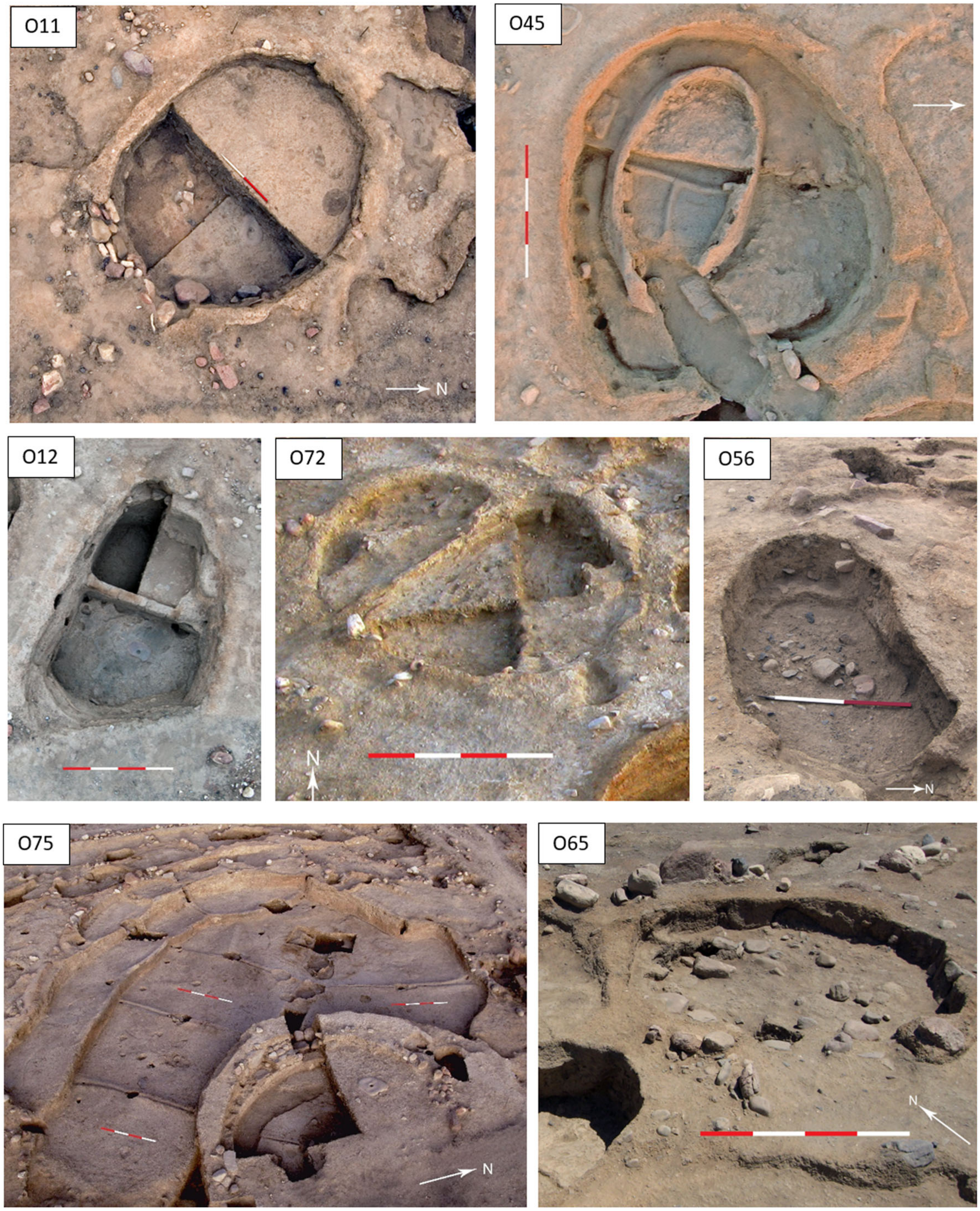

FIGURE 3 A sample of structures/objects at WF16 [Colour figure can be viewed at wileyonlinelibrary.com]

mortar. Although this might simply be the discard of a carcass that was fortuitously spared later disturbance, we note that at Çatalhöyük the wing of a little egret has been included within a closing deposit for an oven (Russell, 2019, 382).

Structure O72 is notable for having a relatively low frequency of Accipitridae, at 75.24%. This is a consequence of a high frequency of bones from the northern bald ibis (NISP = 23; MNI = 3), constituting 11.43% of the assemblage and the largest concentration of this taxa from anywhere at the settlement. Three toe bones and one ungual are considered to be from a single bird, while half of the bones are from the wing, with at least three right wings represented.

3.4 | Seasonality and palaeoenvironmental implications

Based on their modern-day ecology, the bird bones from WF16 suggests a range of different habitats were accessible to the occupants at

TABLE 2 NISP counts by family and object (see Table S1 for further details)

Family	Phase 2											Phase 3	
	O11	O12	O72	O45	O53	O56	O65	O66	O69	O73	O75	O60	O91
Anatidae	2		5	1	1	2			2		11	24	6
Phasianidae	11	7	4	45	17	9	8	2	8	1	71	64	11
Columbidae		1	4	7	1	4	1	1	1		11	18	8
Pteroclidae											1	33	14
Rallidae		1	3	6	1	1			3		4	5	
Gruidae	1			1									
Otididae			1	1			1		1			2	
Ciconiidae	3	1	1	2	5	1		1			9	7	2
Ardeidae								56			1	1	
Threskiornithidae	3	3	24	7	1	2	5		2		7	13	1
Accipitridae	836	179	158	1390	396	362	206	22	256	37	1010	1021	163
Tytonidae		1									1		
Strigidae									3		1	1	1
Coraciidae											2		
Falconidae	1	1	1	3	1	2	3	1	3	6	20	4	2
Corvidae	1	3	8	4		3	5		1		3	6	2
Other passerine	1	1	1	12			2	2		1	9	7	1
Total identified	859	198	210	1479	423	386	231	85	280	45	1161	1206	211
Unidentified	1967	510	238	1496	390	550	247	105	191	44	1267	1142	187
Total	2826	708	448	2975	813	936	478	190	471	89	2428	2348	398

WF16: watery areas (mallard, white stork, little egret), steppe (e.g., buzzard and eagles), rocky slopes (partridge), cliffs and mountains (raven, eagles). Figure 7 illustrates the current seasonal distribution in Jordan of the birds represented (Andrews, 1995; Porter & Aspinall, 2010). Because many of the birds are migrants, we must be cautious about drawing environmental implications for Faynan because migratory birds are often forced to stop and spend the night in almost any kind of environment. Similarly, inferences about seasonal activities at WF16 based on the representation of bird species and their present-day presence is Jordan must consider potential changes in migratory behaviour and environmental change in Faynan since the early Holocene and is subject of further consideration. Nevertheless, on the basis of Figures 2 and 7, it can be suggested that the waterfowl at WF16 were likely captured during the winter months, and a wide range of passage migrants were exploited during the spring and autumn. Most prominent amongst these were buzzards, most likely trapped while resting in Faynan and taken in relatively large numbers compared to other birds.

4 | DISCUSSION

WF16 has provided the largest assemblage of bird bones from a Neolithic site in the southern Levant, and potentially from the whole of SW Asia. In this contribution, we have provided the context for the assemblage, its taxonomic composition, chronological and spatial distribution. While at least sixty-three taxa are represented within the assemblage, it is dominated by the Accipitridae family, and within that by buzzards. This is consistent for the two phases of settlement activity for which bird bones are available, Phase 2 (11.30–10.80 ka BP) and Phase 3 (10.80–10.24 ka BP). In the latter phase, the density of bird bones declines markedly, whereas those of chipped stone and animal bone do the converse, suggesting that bird-related activities became of less significance. There also appears to be a shift towards the exploitation of game birds, notably sandgrouse, although these remain a small proportion of the overall assemblage. These variations occur in the context of a change to free standing circular architecture and rubbish disposal in a large midden that appears to be serving the whole community, which might be interpreted as a greater investment in place, suggesting longer periods of occupation, if not sedentism. During Phase 2, bird bones were discarded in a manner distinct from animal bone and chipped stone. Particularly high densities of bird bones were recovered from two Structures, O11 and O56, and low densities in Structures O73 and O53, with no correlation with the quantities of animal bone and chipped stone.

The wide range of aquatic, game birds and raptors at WF16 is similar to that at Epipalaeolithic and contemporary PPNA sites in the southern Levant (Simmons, 2004; Simmons & Nadel, 1998), suggesting settlements had been located at eco-tone areas to provide access to diverse habitats. While an interest in raptors is evident

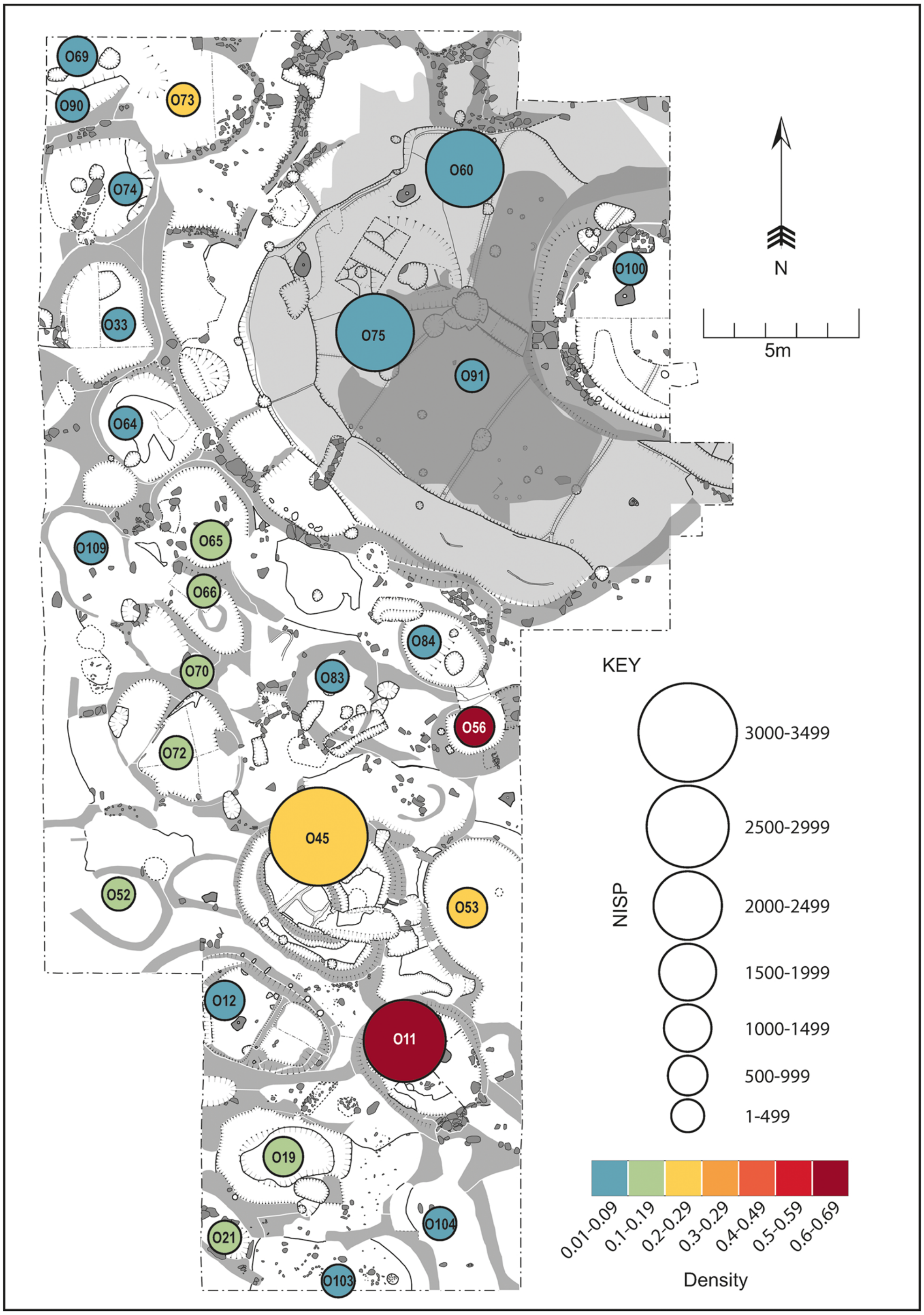

FIGURE 4 Distribution of avian fauna by number of fragments and density within excavated structures at WF16 [Colour figure can be viewed at wileyonlinelibrary.com]

at the early Epipalaeolithic site of Ohalo (Simmons & Nadel, 1998), WF16's focus on raptors at WF16 is shared with later (PPNB) Neolithic sites. At Shkarat Msaied, 30 km south from WF16, 295 of the 300 avian bird bones were from raptors (Bangsgaard, 2008) while Nahel Roded II in the southern Negev has an assemblage dominated by Accipitridae, with the European honey buzzard most prevalent (Birkenfeld et al., 2019). Both assemblages have been interpreted as deriving from hunting birds on their spring and autumn migrations. The focus on buzzards at WF16 suggests a seasonal targeting of this species, similar to the manner in which Late Natufian community at Shubayqa 1 had targeted migratory wildfowl during the winter months (Yeomans & Richter, 2018). The diverse range of species represented at WF16 also has similarities with that from Hallam Çemi in the northern Levant (Zeder & Spitzer, 2016). While Hallam Çemi lacks the focus on raptors (at 17.6% of the NISP, compared with 89.19% at WF16), some of its raptors had been exploited for wings and feathers, potentially for use on costumes for display within communal structures. This remains a possibility for WF16 with its especially large structure, O75, appearing suitable for gatherings and performance. Raptors are also prominent in the fauna and art at Jerf

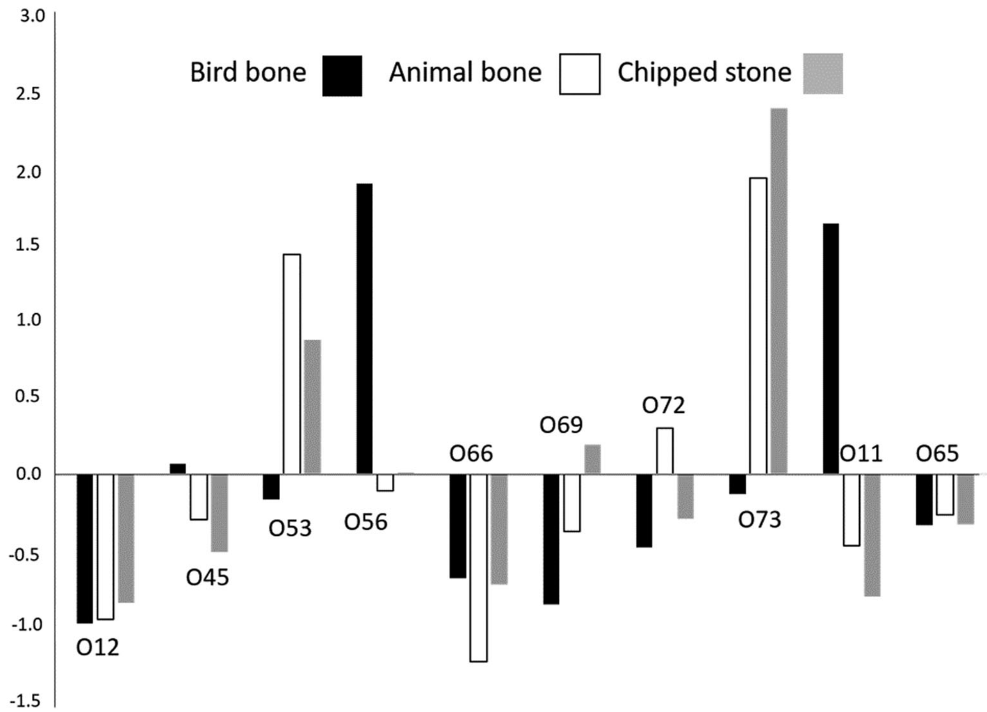

FIGURE 5 Comparison of the distribution of the number of bird bones with the weights of animal bones (grams) and chipped stone (grams) in 10 structures of Phase 2, with the three data sets standardized to enable comparison

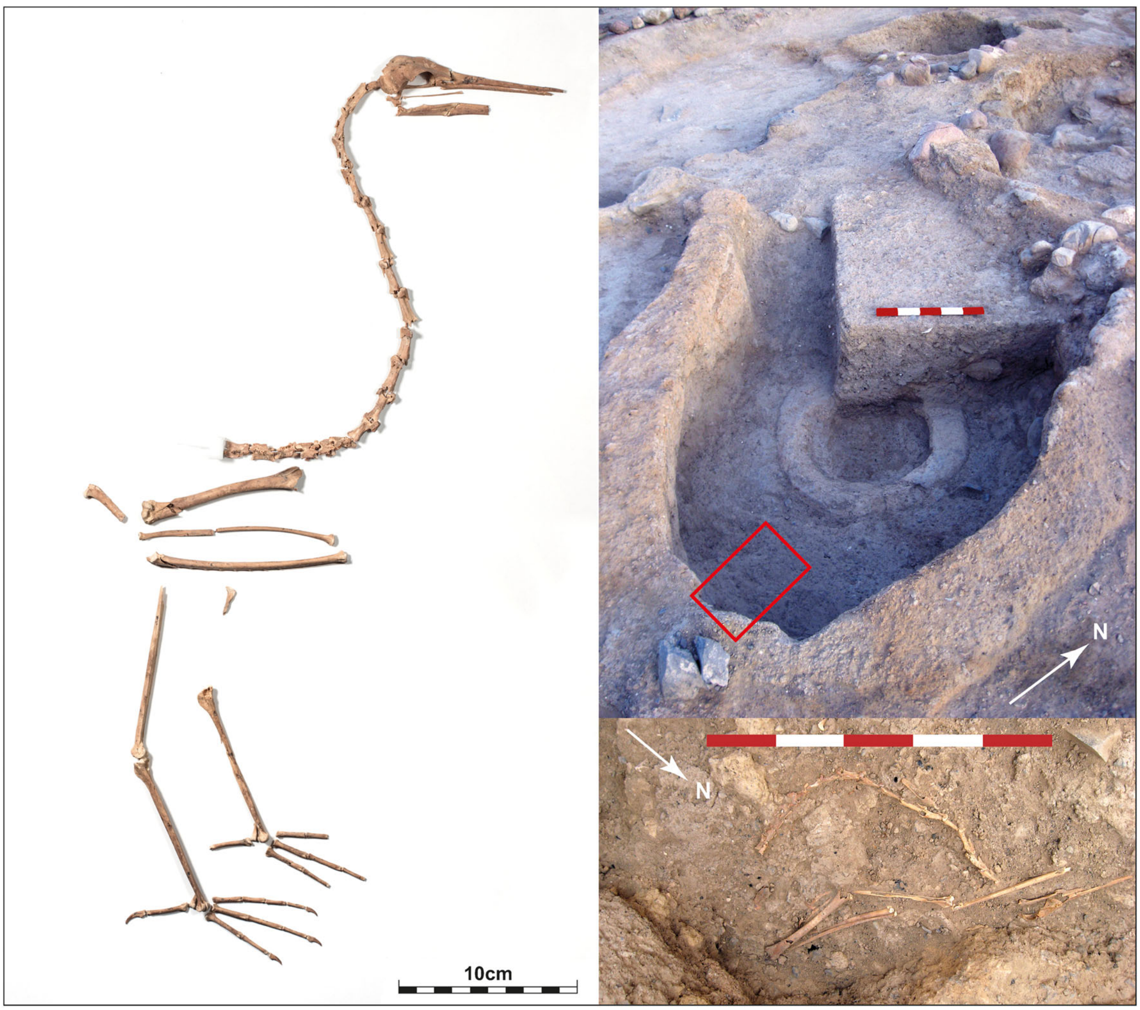

FIGURE 6 Little egret within Structure O66 [Colour figure can be viewed at wileyonlinelibrary.com]

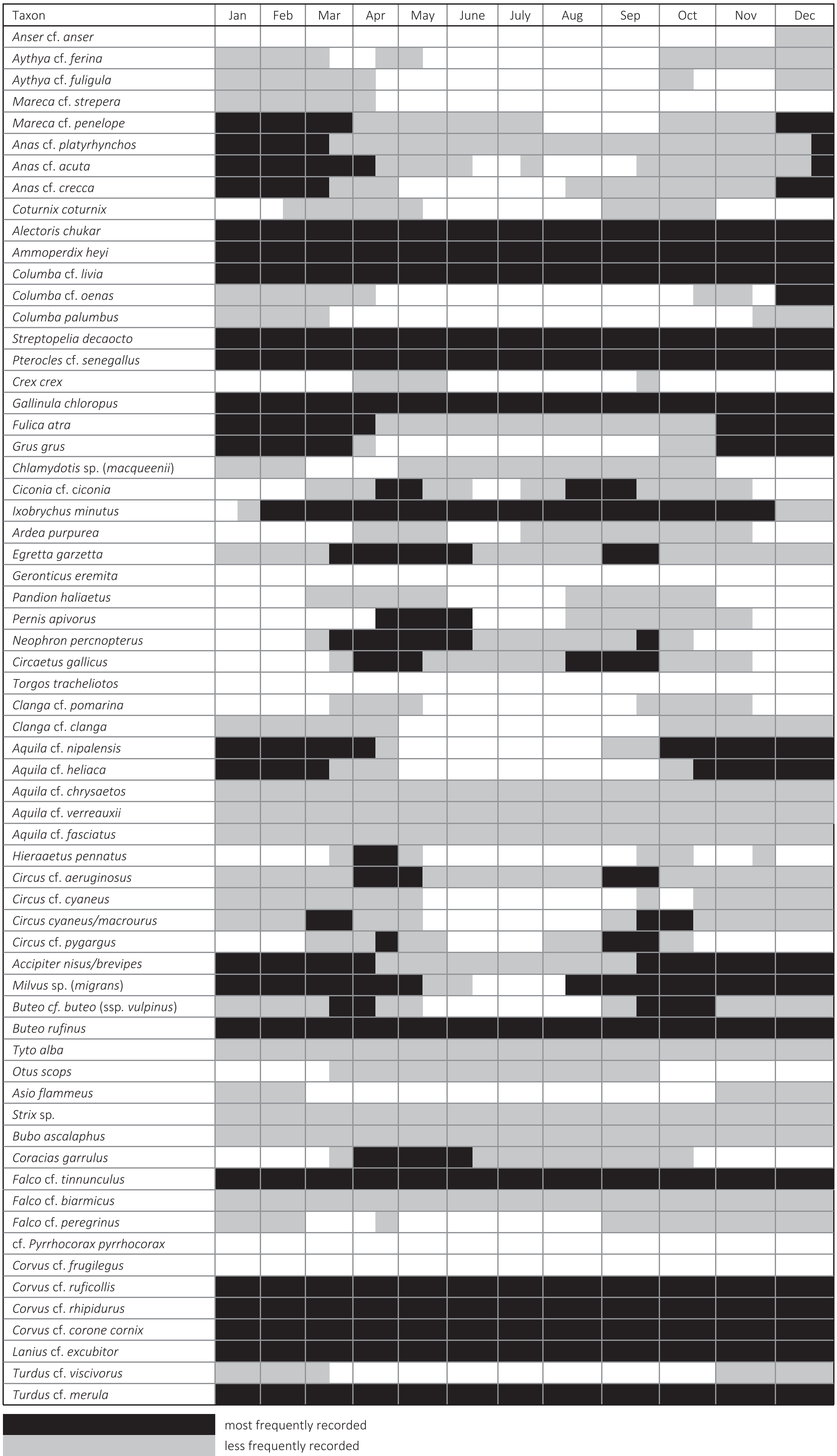

FIGURE 7 Present day seasonal distribution in Jordan of birds represented at WF16 (derived from Andrews, 1995); see also updated list in (http://www.jordanbirdwatch.com/birds-in-jordan/jordan-bird-list/)

el Ahmar and the artworks of Göbekli Tepe (Gourichon, 2002; Peters et al., 2005). This concern with raptors and other large birds in the social and symbolic life of the Neolithic should not be surprising, as such birds play a role in the religious beliefs and ceremonial life of historically recorded societies throughout the world (Cocker & Tipling, 2013). We anticipate that study of cut marks on the raptor bones from WF16 will enable further inferences about their use at this settlement, whether primarily as food or as a source of skins, wings and feathers.

5 | SUMMARY

A complete interpretation of the WF16 avian assemblage requires the analysis of body part representation, cut marks and patterns of burning, along with consideration of the palaeoenvironmental implications of the birds represented, all currently underway. This study has concentrated on assemblage composition and shown the value of acquiring large assemblages of bird bones. Although the 249 NISP acquired from the 1997–2002 WF16 site evaluation demonstrated a similar focus on raptors (Rielley, 2007), that assemblage had failed to capture the diversity of birds represented at WF16, identifying only 10 taxa in contrast to the 63 now recognized. This larger sample has also enabled us to identify that spatial patterning of bird bones differs from that other debris and changes over time in the extent and nature of activity relating to bird exploitation. Overall, the avian assemblage from PPNA WF16 had shown a unique focus on raptors for a settlement of this period.

While the studies of cut marks and body part representation will provide further information about bird use at WF16, the value of the site's avian assemblage arises via comparison with those from other sites, thus enabling us to explore how people–bird relationships varied across SW Asia and through the Neolithic transition from mobile hunting and gathering to settled farming communities. A pattern is emerging of a persistent interest in raptors from the early Epipalaeolithic to the PPNB, the utilization of wildfowl and game birds as food, the exploitation of a wide range of birds taxa that suggests their use for many purposes, and that settlements had been located with access to diverse habitats.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available in the Supporting Information of this article. Requests for additional data can be sent to the corresponding author.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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